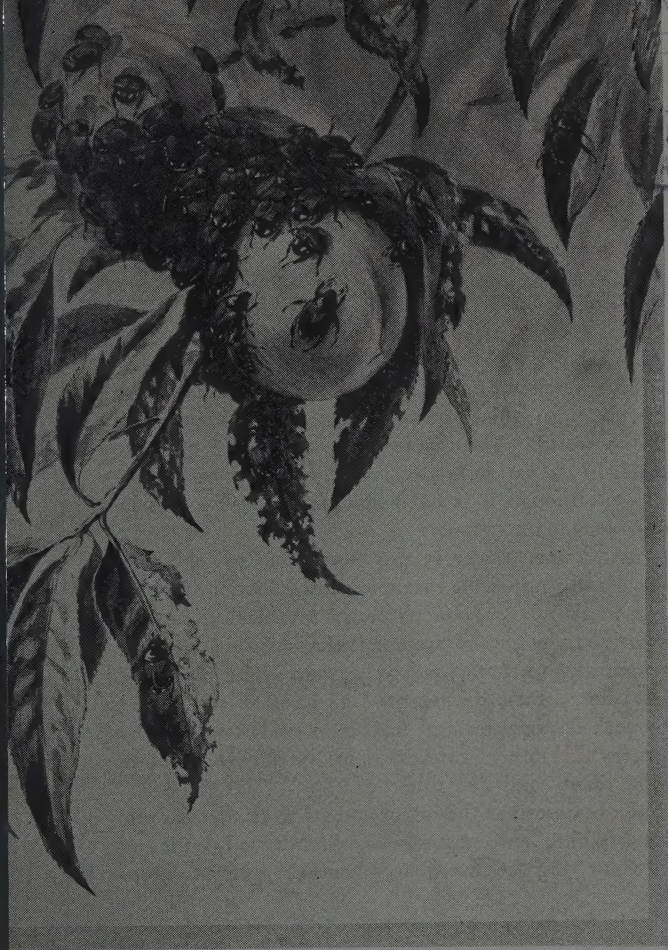
...P. INST. ENT
LIBRARY
1 0NOV 1941
...IAL U.S.A.69
...ARATE



E & A

The JAPANESE BEETLE AND ITS CONTROL

FARMERS' BULLETIN
~ ~ NO. 1856 ~ ~
U.S. DEPARTMENT of AGRICULTURE

1940

IT IS WELL KNOWN that many of our more serious insect pests of today are not native to the United States but have been brought into this country accidentally from other parts of the world. The Japanese beetle is one of these immigrants; in its native home, Japan, it occurs on all the main islands although it is not sufficiently abundant to be a pest of economic importance.

In its new home, however, this insect has so far found conditions ideally suited for its rapid multiplication, favored host plants in abundance, and an almost total lack of natural enemies native to its new environment that are able to hinder its development to any marked extent. The Japanese beetle, therefore, must be accepted as another pest to be reckoned with by farmers and fruit growers, as well as by home owners and others interested in the development of ornamental plants and fine turf.

This bulletin describes the insect and its work, its seasonal history and habits, and the methods which have been found useful in destroying the insect or preventing injury to crops and plants.

Washington, D. C. Issued October 1, 1940

cat.

THE JAPANESE BEETLE AND ITS CONTROL

E.M.N.

By C. H. HADLEY, *principal entomologist, Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine*

Contents

	Page
History and occurrence in the United States	1
How to recognize the Japanese beetle in its different stages	1
Seasonal history and habits	2
Feeding habits and food plants of the beetle	5
Feeding habits of the larva	9
Effect of climate and natural enemies upon beetle abundance	11
Control measures	12
Use of trees, shrubs, and plants not fed on by the Japanese beetle	12
Reducing beetle populations on the premises	13
By hand collection and jarring	13
Control measures—Continued	
By contact sprays	13
By traps	14
Protecting food plants from beetle attack	15
Repellent sprays and their preparation	16
Protecting shade trees	18
Protecting fruit trees	18
Protecting small fruits	19
Protecting shrubs and ornamentals	20
Protecting vegetables	20
Preventing injury from grubs, or larvae	21
Grubproofing lawns and other turf areas	21
Treatment of flower beds and gardens	22

HISTORY AND OCCURRENCE IN THE UNITED STATES

THE JAPANESE BEETLE (*Popillia japonica* Newm.) is an insect native to Japan. It was accidentally introduced into the United States some time prior to 1916, when it was first found in this country near Riverton, N. J. Since that time the infestation has increased and spread outward at a relatively rapid rate. By the close of the summer of 1939 the area of general distribution covered 16,300 square miles in 6 States, and local colony centers were known to exist in most of the States east of the Mississippi River, as shown in figure 1. It will be noted that the infestation is much more general and continuous along the Atlantic seaboard than in the States to the westward.

HOW TO RECOGNIZE THE JAPANESE BEETLE IN ITS DIFFERENT STAGES

The various stages of the Japanese beetle are shown in plate 1. The adult beetle is nearly half an inch long, about one-fourth inch wide, broadly oval, and shining metallic green. The hard outer wings are coppery brown. There are two small tufts of white hairs just behind the wing covers and five patches along each side of the body, which make the Japanese beetle readily distinguishable from other beetles often mistaken for it (plate 2).

The eggs are elliptical, translucent, one-sixteenth to one-eighth inch in diameter, and white or cream-colored.

The newly hatched larva, or grub, is about one-sixteenth inch in length, has three pairs of legs, and has the general shape of a blunt-ended crescent. When fully grown (fig. 2), it is about an inch long

and resembles in general appearance the larvae of June beetles, commonly known as "white grubs" or "grubworms."

The pupa, or the stage in which the grub transforms to the adult beetle, has a pale-cream to tan color and is about one-half inch long and one-fourth inch wide.

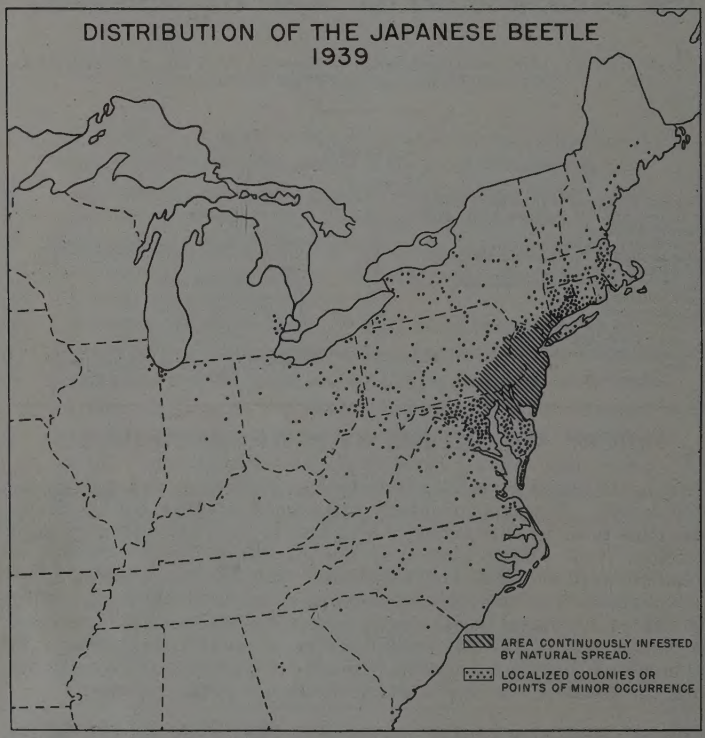

DISTRIBUTION OF THE JAPANESE BEETLE
1939
AREA CONTINUOUSLY INFESTED BY NATURAL SPREAD.
LOCALIZED COLONIES OR POINTS OF MINOR OCCURRENCE

FIGURE 1.—Distribution of the Japanese beetle through 1939. The shaded area indicates the area of general or continuous infestation; the dots indicate places at which local colonies have been found.

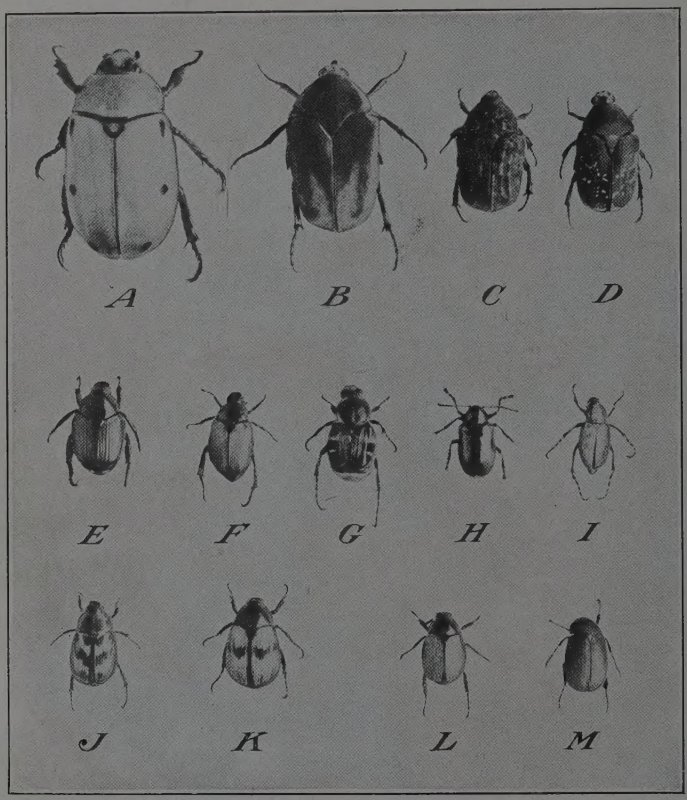
SEASONAL HISTORY AND HABITS [1]

The life cycle of the beetle, shown diagrammatically in figure 3, normally requires 1 year. The larval stage continues from the time the eggs hatch in summer through the fall and winter and until the latter part of May or early in June of the following year. During the summer and early in the fall the larvae are mostly in the upper 3 inches of the soil, feeding on plant roots; as winter approaches they go down to a depth of 4 to 8 inches, moving nearer to the surface the following spring.

[1] For a more complete discussion, see U. S. Department of Agriculture Circular 332, General Information about the Japanese Beetle in the United States.

JAPANESE BEETLE

Stages of the Japanese beetle. Adult beetles feeding on fruit and leaves, about one-half natural size. Insert, adult beetle, about twice natural size. Figures below, left to right, mature grub, pupa, beetle laying eggs, and developing grubs, all about twice natural size.



The Japanese beetle and other beetles sometimes mistaken for it: *A*, Spotted Pelidnota (*P. punctata* (L.)); *B*, green June beetle (*Cotinis nitida* (L.)); *C*, bumble-flower beetle (*Euphoria inda* (L.)); *D*, *E. herbacea* (Oliv.); *E*, Japanese beetle (*Popillia japonica* Newm.); *F*, *Strigoderma arboricola* (F.)); *G*, *Trichiotinus piger* (F.); *H*, milkweed beetle (*Chrysochus auratus* (F.)); *I*, rose chafer (*Macrodactylus subspinosus* (F.)); *J*, oriental beetle (*Anomala orientalis* Waterh.); *K*, *A. binotata* Gyll.; *L*, *Pachystethus luciola* (F.)); *M*, Asiatic garden beetle (*Autoserica castanea* Arr.).

In the latitude of Philadelphia the first Japanese beetles usually begin to emerge from the soil between June 10 and 20, and in an average season they are present in considerable numbers by July 5. The peak of the feeding season usually occurs the last of July or the early part of August, and thereafter the dead bodies of the beetles may be readily found beneath the plants on which they have been feeding. The normal life of a beetle is from 30 to 45 days, but since all the beetles do not emerge at one time, a few may be found as late

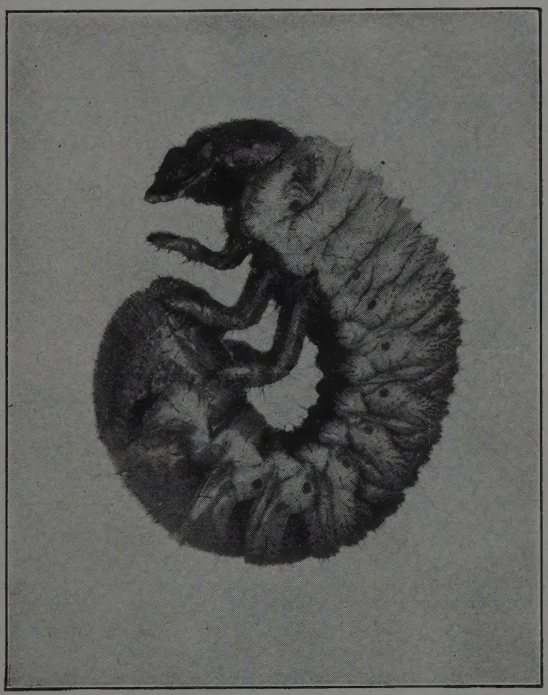


FIGURE 2.—Full-grown larva of the Japanese beetle. About five times natural size.

as October. At more southern points the period of beetle activity occurs earlier in the season; farther north, it occurs later.

On warm, sunny days the beetles feed and fly about actively, going from one plant to another. They tend to collect in groups and to feed on certain plants, leaving others, apparently equally attractive, untouched. For laying their eggs the beetles prefer medium-moist, loamy soil with closely cropped grass, such as is found in lawns, pastures, and golf greens and fairways, but some eggs are always placed in less favorable situations, such as flower beds and cultivated ground. After burrowing to a depth of 2 to 4 inches, the female beetle deposits from 1 to 3 or 4 eggs at one time, usually at night. She then emerges and, after spending several days in feeding, returns to the soil to deposit another lot of eggs. This procedure goes on until a total of from 40 to 60 eggs have been laid.

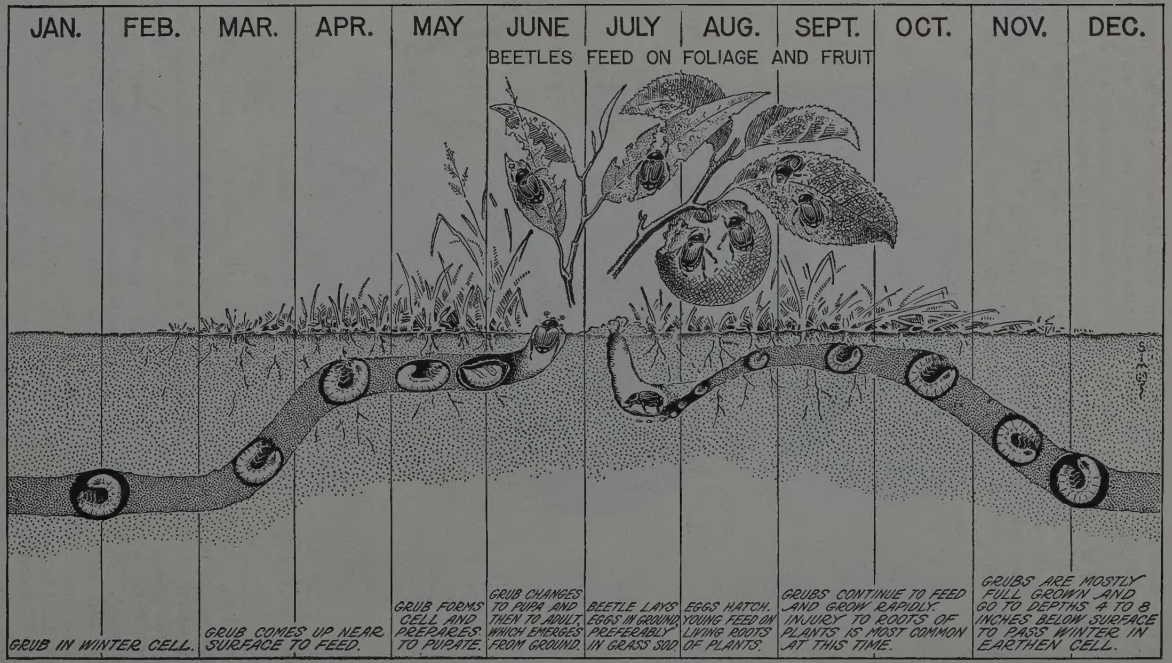

JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
BEETLES FEED ON FOLIAGE AND FRUIT
GRUB IN WINTER CELL.
GRUB COMES UP NEAR SURFACE TO FEED.
GRUB FORMS CELL AND PREPARES TO PUPATE.
GRUB CHANGES TO PUPA AND THEN TO ADULT, WHICH EMERGES FROM GROUND.
BEETLE LAYS EGGS IN GROUND PREFERABLY IN GRASS SOD
EGGS HATCH. YOUNG FEED ON LIVING ROOTS OF PLANTS.
GRUBS CONTINUE TO FEED AND GROW RAPIDLY. INJURY TO ROOTS OF PLANTS IS MOST COMMON AT THIS TIME.
GRUBS ARE MOSTLY FULL GROWN AND GO TO DEPTHS 4 TO 8 INCHES BELOW SURFACE TO PASS WINTER IN EARTHEN CELL.

FIGURE 3.—Diagrammatic representation of the seasonal life cycle of the Japanese beetle.

The eggs hatch about 2 weeks after they are laid. The newly hatched larva, or grub, begins at once to feed on the roots of grasses and other plants, and by the latter part of September it is from ¾ to 1 inch in length. Growth is completed the following spring.

FEEDING HABITS AND FOOD PLANTS OF THE BEETLE

The injury caused by the feeding of the adult beetle on foliage and fruit is conspicuous. Feeding is confined chiefly to the foliage on the upper and outer parts of plants and trees exposed to bright sunlight and takes place during the warmer part of the day. On cloudy or cool days there is almost no feeding. The beetles consume the tissue between the veins of the leaves, causing the leaves to become wholly or partly skeletonized (fig. 4). Leaves which have been thus attacked

FIGURE 4.—Grape leaf destroyed by the feeding of Japanese beetles. The soft tissues have all been eaten, leaving only the network of veins.

soon turn brown and fall, and as a result preferred food plants in heavily infested areas are often entirely stripped of their foliage. When the infestation is very severe, even large fruit and shade trees may be completely defoliated within a few days (fig. 5).

The beetle is also a pest of considerable importance on early-ripening fruits, especially apples, peaches, and plums. The feeding on such fruits is often very severe, as the beetles congregate in masses on the fruit and eat into the juicy interior until only the core, stone, or pit is left (fig. 6). Prematurely ripened or imperfect fruits are preferred, but where the infestation is heavy, nearly all the fruit may be injured. Late varieties of fruits usually escape attack.

Beetles also cause much injury to field and sweet corn by feeding on the silk as it grows out from the husk, before pollination takes place (fig. 7). The destruction of the green immature silk prevents pollination and subsequent development of the kernels (fig. 8). Among field crops other than corn, soybean and red clover are most likely to be severely attacked. Of the truck crops, asparagus, rhubarb, and beans are most susceptible.

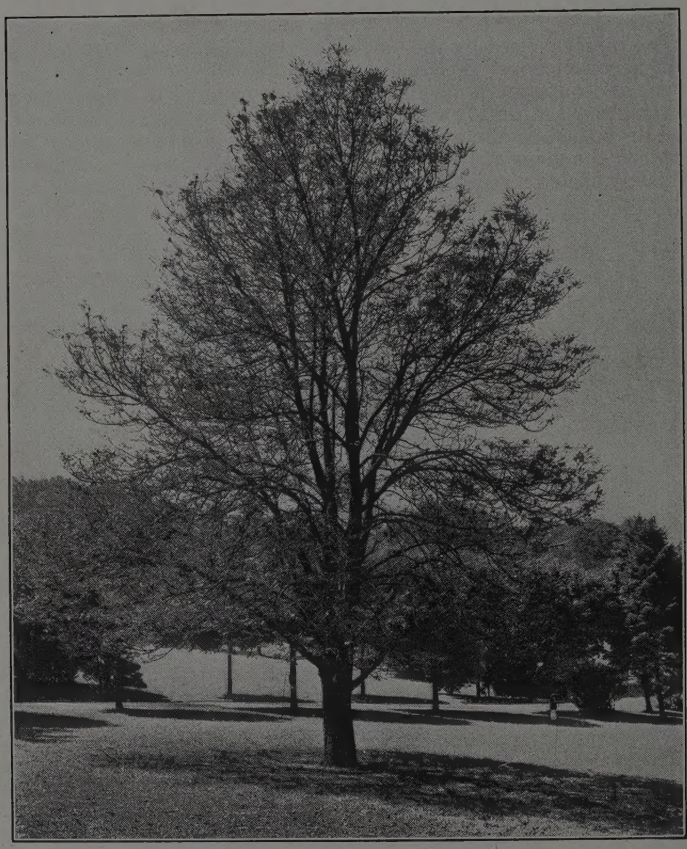


FIGURE 5.—Horsechestnut injured by the feeding of Japanese beetles.

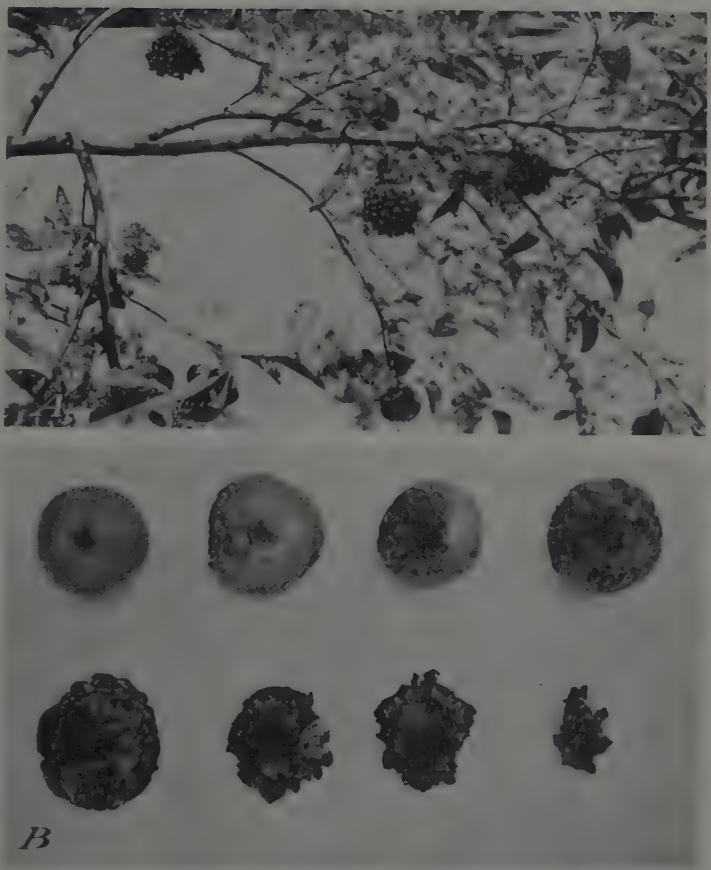


FIGURE 6.—Japanese beetles feeding on apple: *A*, Beetles clustered on the ripening fruits; *B*, typical injury to fruit, ranging from slight damage to complete consumption of the skin and pulp.

236502°—40——2

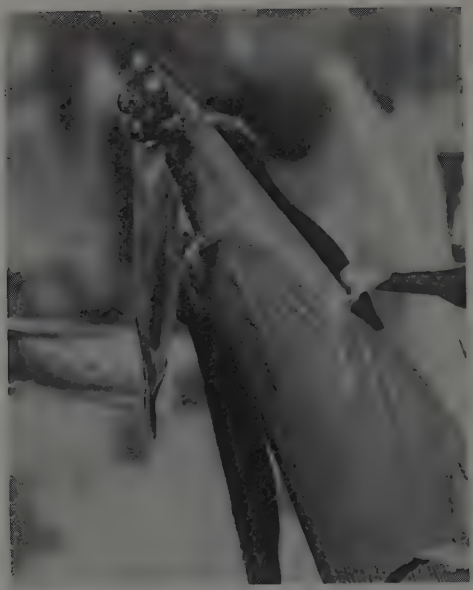


FIGURE 7.—Beetles feeding on the silk at the tip of an ear of field corn.

FIGURE 8.—Typical imperfect pollination of corn resulting from Japanese beetle feeding on silk.

The Japanese beetle is known to feed on more than 260 different plants, but most of the injury is confined to a limited number of the more favored species. Those most frequently attacked are listed below, those marked with an asterisk (*) being preferred. Only the foliage is eaten unless otherwise noted. A list of the more common trees and plants that are rarely attacked is given on pages 12 and 13.

Small fruits:
- Blackberry, foliage and fruit
- Blueberry and huckleberry, foliage and fruit
- Currant, red varieties
- *Grape
- *Raspberry, foliage and fruit

Orchard fruits:
- *Apple, foliage and especially fruit of early ripening varieties
- *Cherry
- Peach; injury severe on fruit of early ripening varieties and occasionally severe on foliage
- Plum, foliage and fruit
- Quince

Truck and garden crops:
- Asparagus
- Beans
- Rhubarb
- *Sweet corn, foliage, silk, and ear

Field crops:
- Alfalfa
- Clover, foliage and flowers
- *Field corn, foliage, silk, and ear
- *Soybean

Ornamental shrubs and vines:
- Barberry
- Butterflybush, flowers only
- Crapemyrtle, foliage and flowers
- Lespedeza
- Oriental flowering cherry
- *Rose, foliage, buds, and flowers
- *Shrub-althea, flowers
- *Virginia creeper

Flowering garden plants:
- Canna, foliage and flowers
- *Dahlia, foliage and flowers
- *Hollyhock, foliage and flowers
- *Marshmallow, foliage and flowers
- Rosemallow, foliage and flowers
- Snapdragon, especially flowers of dark-colored varieties
- *Zinnia

Shade trees:
- *Elm
- *Horsechestnut
- *Linden
- *Lombardy poplar
- *Norway maple
- Pin oak
- Planetree or buttonwood
- White birch
- *Willow

Weeds and other noneconomic plants:
- Alder
- *Bracken
- Dock
- *Elder
- *Evening primrose, foliage and flowers
- *Indian mallow or velvetleaf
- *Sassafras
- *Sensitive fern
- *Smartweed, foliage and flowers
- Tear thumb
- *Wild fox grape
- *Wild summer grape

FEEDING HABITS OF THE LARVA

The larvae, or grubs, of the Japanese beetle frequently cause severe injury to turf in lawns, golf courses, parks, and pastures. As they burrow through the soil, the larvae cut and feed on the rootlets of grass, causing it to die out in small patches or larger areas (fig. 9). Turf killed in this manner can be rolled back easily, disclosing the larvae beneath (fig. 10). Considerable injury is also caused at times by the grubs feeding on the roots of strawberry, corn, bean, tomato, beet, onion, and other vegetables, and ornamentals, such as iris, peony, gladiolus, snapdragon, and others. Some varieties of nursery stock have at times been severely injured by the larvae girdling the main roots at depths of from ½ to 1½ inches below the surface of the ground.

FIGURE 9.—Light areas of this lawn are dead sod killed by the feeding of larvae of the Japanese beetle on the roots.

FIGURE 10.—Dead turf rolled back exposing Japanese beetle larvae which have been feeding on the roots.

EFFECT OF CLIMATE AND NATURAL ENEMIES UPON BEETLE ABUNDANCE

A study of conditions in Japan, the native home of the beetle, as compared with those obtaining in various parts of the United States indicates that the beetle will be able to develop in most of this country east of western Kansas. In the more northern parts of New England and in the interior region north of Illinois, Missouri, and Nebraska it is possible that winter temperatures may be low enough at times to prove fatal to many of the larvae, especially when there is an absence or scarcity of snow. In much of the more arid western part of the United States the insect probably will not develop because of the general dryness of the region and the deficient summer rainfall, though

FIGURE 11.—Female of the Japanese *Tiphia*. Four times natural size.

it may be possible for it to maintain itself where irrigation is practiced extensively.

Studies of our native parasites and predators of white grubs have shown that thus far none of these have brought about any marked control of the introduced Japanese beetle. A number of the more important parasites of this pest have been brought in from the Orient, and five of these species are now established in this country within the area heavily infested by the beetle. Three of these introduced parasitic insects have met adverse conditions, which have retarded their spread and rapid increase, but two of them, the spring *Tiphia* from Korea and the fall *Tiphia* from Japan (fig. 11), have now become well established in the area first inhabited by the Japanese beetle and are becoming a factor of value in the natural control of the pest.

As rapidly as facilities permit, the Department of Agriculture is placing colonies of these parasites at favorable points throughout the areas infested by the Japanese beetle. Once established, it is expected that these enemies of the beetle will gradually spread over all nearby infested territory and thus become important in the natural control of the beetle. The Department is not in a position to furnish parasites in response to requests from individuals or local groups.

It is known that various soil-inhabiting microorganisms, such as bacteria, fungi, protozoans, and nematodes, destroy the larvae of the

Japanese beetle. Two types of bacteria causing the so-called "milky diseases" of the larvae have been studied extensively, and efforts are being made to culture and distribute these organisms throughout the areas infested by the beetle as a means of increasing natural control of the pest.

A number of our common birds feed readily upon Japanese beetles. Some of the more important are the purple grackle, European starling, cardinal, meadowlark, catbird, English sparrow, and robin. Birds also dig up and devour large numbers of larvae in heavily infested areas, especially the European starling, purple grackle, and crow. In cultivated land, chickens, turkeys, and gulls will destroy many of the larvae when fields are being plowed or cultivated.

Some of our common mammals having more or less subterranean habits feed on the larvae. The more useful of these animals are the common mole, the large short-tailed shrew, the skunk, and the pine mouse.

CONTROL MEASURES

USE OF TREES, SHRUBS, AND PLANTS NOT FED ON BY THE JAPANESE BEETLE

Although the Japanese beetle is known to feed on more than 260 different plants, of which those most seriously attacked have already been mentioned, there are a number that are rarely or never fed upon. In planning new plantings or modifying established plantings, the home owner can well consider the more extensive use of trees, shrubs, or plants that are not preferred by the beetle. The following list of the more common trees and plants that are rarely attacked by the Japanese beetle may be helpful in the choice of plants or trees to use in areas in which this insect is a problem.

Small fruits:
- Dewberry
- Gooseberry

Orchard fruits, pear

Truck and garden crops:
- Cabbage
- Carrot
- Cauliflower
- Eggplant
- Lettuce
- Onion
- Parsley
- Pea
- Potato
- Radish
- Spinach
- Squash
- Sweetpotato
- Tomato
- Turnip

Field crops:
- Barley
- Oats
- Rye
- Wheat

Ornamental shrubs and vines:
- All evergreens
- Azalea (except deciduous varieties)
- Beautyberry

Ornamental shrubs and vines—Con.
- Box
- Clematis
- Deutzia
- English ivy
- Euonymus
- Forsythia
- Honeysuckle
- Hydrangea
- Lilac
- Mockorange
- Privet
- Rhododendron
- Snowberry
- Spirea
- Weigela
- Wisteria

Ornamental garden plants:
- Aquilegia or columbine
- Calendula
- Carnation
- Chrysanthemum
- Coreopsis
- Cosmos
- Four-o'clock
- Gladiolus
- Goldenglow
- Iris
- Larkspur
- Lily

Ornamental garden plants—Con.
- Nasturtium
- Pachysandra
- Pansy
- Peony
- Petunia
- Phlox
- Poppy
- Snapdragon (light-colored varieties)
- Sweet pea
- Tulip
- Violet

Shade trees:
- All evergreens (except cypress)

Shade trees—Con.
- Ash
- Beech
- Carolina poplar
- Catalpa
- Dogwood
- Locust
- Maples (except Norway and Japanese)
- Oaks (except pin and chestnut)
- Redbud
- Sweetgum
- Tupelo or sourgum
- White poplar

REDUCING BEETLE POPULATIONS ON THE PREMISES

Any method by which the number of beetles on the premises may be reduced will be of benefit in delaying the natural increase in the beetle population, as well as affording some protection to the plants.

By Hand Collection and Jarring

In the early stages of an infestation, collecting the beetles by hand from their food plants is of some value, especially if done regularly and thoroughly throughout the beetle season. One of the easiest methods of removing beetles from heavily infested plants is by jarring early in the morning, when the temperature is low and the beetles are sluggish. Sheets should be placed under the plant to catch the beetles as they fall. The beetles may then be killed by being dropped into a pail containing water and kerosene. Beetles may be removed in this manner from larger trees or shrubs by shaking individual branches. This practice does not, however, prevent reinfestation from outside sources.

By Contact Sprays

Large numbers of beetles can be killed by the use of contact sprays, which kill by coming into direct contact with the body of the insect. The effectiveness of contact sprays against the Japanese beetle depends mainly upon the insect being thoroughly wetted by the spray. A coarse drenching spray is best for this purpose. A satisfactory contact spray for the Japanese beetle is one composed of sodium oleate and an alcoholic extract of pyrethrum flowers diluted with water. Proprietary sprays containing these ingredients are sold by reliable dealers in insecticides, and when used according to the directions they are usually satisfactory. Soap sprays, made of commercial fish-oil soap or one of the better grades of household soaps, dissolved at the rate of 1 pound of soap to 3 or 4 gallons of water, are also useful for killing beetles. The soap should first be dissolved in a little warm water, the full quantity of water then being added.

Contact sprays are most effective if used between 10 a. m. and 4 p. m., when the sun is shining, the temperature above 80° F., and the relative humidity low. Under these conditions the beetles are most active and most susceptible to these sprays. It must be remembered that, although large numbers of beetles can be killed by contact sprays, these sprays do not leave a repellent residue on the foliage and, therefore, will not prevent plants from becoming reinfested, and also that

repeated applications of these sprays may cause some injury to the plants.

By Traps

Traps designed to catch Japanese beetles have been used for a number of years. Traps of several types are available; when properly placed and cared for, they offer an easy and inexpensive method for destroying large numbers of beetles. A satisfactory trap should embody the essential features of the type developed by Department workers (fig. 12), which are as follows: A four-winged baffle on top of

FIGURE 12.—Standard Japanese beetle trap painted solid yellow.

and projecting into a funnel, to which is attached a container for holding the captured beetles. Recent tests have shown that traps painted a primary-yellow color will catch more beetles than the same traps painted green and white, as was heretofore generally recommended. The most attractive bait is a mixture composed of 10 parts of geraniol and 1 part of eugenol. The best method of dispensing the bait is by means of a bottle and wick, placed preferably in the center of the baffle and protected from rain.[2]

[2] For more detailed information on the use of traps, see U. S. Department of Agriculture Miscellaneous Publication 201, Traps for the Japanese Beetle and How to Use Them.

Under conditions of light to moderate infestation, the consistent and general use of traps will be of some value in delaying the normally rapid increase in the beetle population. In areas where beetles are present in such numbers that serious injury to food plants occurs, however, traps may capture tremendous numbers of beetles without causing any appreciable reduction in the beetle population or the extent of feeding on a given property. Under such conditions little benefit is derived by the individual property owner from using traps unless his efforts are supported by his neighbors in community effort. In any event, however, within heavily infested areas, traps alone cannot be depended on to give complete protection of favored food plants from beetle attack; such protection can best be obtained by the use of the protective sprays referred to hereafter.

The United States Department of Agriculture has made extensive use of traps along the margins of the infested area and elsewhere, to obtain information on the distribution of the insect in connection with efforts to retard its spread to new areas. With this exception, the Department does not place traps on private property, nor does it have traps available for distribution to individuals or community groups.

PROTECTING FOOD PLANTS FROM BEETLE ATTACK

The need for the application of specific control measures against the Japanese beetle in any locality depends largely on the relative density of the beetle population. Under conditions of light to moderate beetle abundance there is usually little need for the application of control measures designed primarily to protect shade trees, orchards, and other plant groups from beetle attack; the control practices customarily used for protection against other foliage-eating insects usually provide adequate protection. On the other hand, under conditions of heavy beetle infestation these measures frequently fail to give adequate protection, and additional measures aimed directly at the beetle are necessary. The control measures discussed hereafter are applicable where the beetle population is sufficiently dense to cause injury.

The foliage and fruit of susceptible food plants can be protected from beetle attack by the application of sprays which leave a deposit repellent to the beetle. Thus the protection is obtained largely by rendering the food plant nonattractive rather than by poisoning the beetle. Timeliness and thoroughness in the application of the repellent sprays are most important. As a general rule the spray should be applied as soon as the first beetles appear in the vicinity and before feeding becomes general. Additional applications may be needed, depending on the weather and the growth of the plant, and should be made as soon as the need is apparent. The sprays must be applied in a thorough manner, so that all portions of the tree or plant upon which the beetles may feed are well covered by the spray. It is especially important that the spray coating on the leaves be complete and uniform (fig. 13). High-pressure spray equipment is necessary to apply the sprays properly to fruit and shade trees (fig. 14) and the higher ornamental shrubs; hand-operated wheelbarrow, bucket, or compressed-air sprayers can be used for low-growing plants.

As diseased and poorly nourished trees and plants are especially susceptible to attack, they should be maintained in a healthy, vigorous condition by the proper use of fertilizers and other appropriate measures.

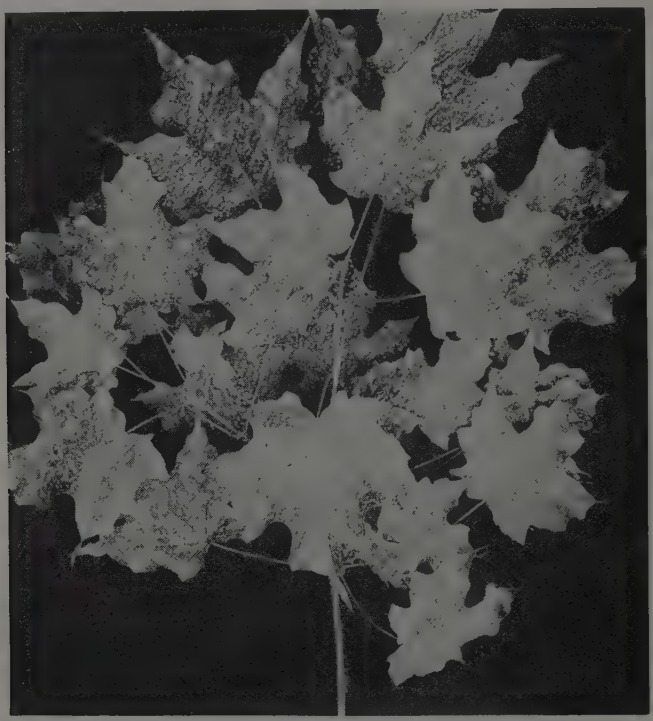


FIGURE 13.—The foliage must be well covered with spray for protection against Japanese beetle feeding.

Repellent Sprays and Their Preparation

The following repellent sprays have been tested experimentally and are recommended and are being used successfully under field conditions in the older infested areas:

Lead arsenate spray [3]

Ingredients:	*Quantity required to make—* *10 gallons*	*100 gallons*
Lead arsenate (powdered)	10 ounces.	6 pounds.
Wheat flour	6 ounces.	4 pounds.
Water	10 gallons.	100 gallons.

To prepare this spray, weigh the flour and mix it thoroughly with a small quantity of cold water to make a thin paste. Wash the dry

[3] Only the form of lead arsenate commonly sold as a powder and used for agricultural spray purposes is advised. This is acid lead arsenate; it should contain at least 30 percent of arsenic pentoxide (As_2O_5) and not more than 0.75 percent of water-soluble arsenic, expressed as metallic arsenic.

lead arsenate directly into the sprayer tank and add the flour paste while the tank is partly filled with water and the agitator is in motion. Then add the remainder of the required quantity of water.

In this spray the flour is used as a sticker to increase the adhesiveness of the poison to foliage. When the spray is to be used on shade trees, other stickers, such as raw linseed oil or fish oil,[4] may be substituted for the flour at the rate of 4 fluid ounces of the oil to each pound of lead arsenate.

Precautions in using lead arsenate.—Lead arsenate is poisonous to man and animals. Care should be exercised in handling it to avoid

FIGURE 14.—High-powered equipment is necessary for spraying tall shade trees.

inhaling the dust. In mixing or handling it, it is advisable to protect the hands to avoid any possible absorption of the poison into the system through cuts or abrasions of the skin. When using this material, keep the hands away from the mouth and wash them thoroughly before eating. The material should be kept in closed containers, properly labeled, and stored where it will not be accessible to children or domestic animals.

Lime-aluminum sulfate spray

Ingredients:	Quantity required to make— 10 gallons	100 gallons
Hydrated lime (for spraying purposes)	2 pounds.	20 pounds.
Aluminum sulfate	½ pound.	3 pounds.
Water	10 gallons.	100 gallons.

To prepare this spray, dissolve the aluminum sulfate in about 1 quart of water (or 2 gallons when preparing 100 gallons of spray) and

[4] Fish oil with a saponification value of 190 to 198, a specific gravity of 0.927 to 0.933 at 15° C., an iodine number of 139 to 193, and free-fatty-acid content of less than 5 percent should be used.

add it to the partly filled spray tank while the agitator is in motion. Then make a thin paste of the lime and wash it through a screen (to remove any lumps) into the spray tank, and add the remainder of the required quantity of water.

Rotenone-rosin emulsion spray

Ingredients:	Quantity required to make— 10 gallons	100 gallons
Rotenone-bearing material	5 ounces	3 pounds
Rosin-residue emulsion	5½ ounces	3 pounds
Water	10 gallons	100 gallons

As the source of rotenone for this spray, ground derris, cube, or timbo may be used, provided the material contains not less than 4 percent of rotenone and not less than 16 percent of total extractives. The rosin emulsion is made from rosin residue, emulsified by ammonium caseinate, and can usually be obtained in the emulsified form from insecticide dealers.

To prepare the spray, wash the rosin emulsion into the partly filled spray tank. Make the rotenone into a thin paste with water and wash it into the tank with the agitator running, and add the remainder of the required quantity of water.

Protecting Shade Trees [5]

Shade trees subject to beetle attack should be sprayed with the lead arsenate spray as soon as the first beetles appear. Although this spray is principally of value against the Japanese beetle as a repellent, it is a stomach poison and therefore will be of additional value in controlling other leaf-feeding insects.

The use of a lead arsenate spray is sometimes objectionable when it is applied in close proximity to residences, as the spray residue may discolor painted surfaces. In such cases the lime-aluminum spray may be substituted, although under conditions of very heavy infestation it is not so effective as the lead arsenate spray.

These spray materials adhere well to the foliage, but a second application may be needed 2 or 3 weeks after the initial application. If frequent or heavy rains follow the first application, a second one will be needed to maintain protection from attack during the beetle season.

Protecting Fruit Trees [5]

Fruits Ripening Before the Beetles Appear.—The cherry crop is usually harvested before the beetle appears in sufficient numbers to injure the fruit. After the cherries are removed from the trees, the foliage can be protected by spraying with lead arsenate. It may be necessary to repeat the application 2 or 3 weeks later to afford protection throughout the summer.

Some varieties of nectarines ripen sufficiently to be harvested before the beetle seriously injures the fruit. The foliage of these varieties can usually be protected by making two or three applications of the lime-aluminum sulfate spray.

Fruits Ripening at the Height of the Beetle Season.—The apples, peaches, nectarines, and plums which ripen during July and early in August are the most severely attacked and are the most diffi-

[5] For more detailed information on protecting fruit and shade trees, see U. S. Department of Agriculture Circular 237, Control of the Japanese Beetle on Fruit and Shade Trees.

cult to protect. Prematurely ripening or diseased fruit should be removed from the trees, as such fruit is attacked by the beetles even when thoroughly coated with the spray residue; and when these are consumed the beetles begin to feed on the sound fruit. All drops should also be removed, as their odor attracts beetles to the trees under which they are lying. Vigorous effort, particularly during the last 10 days before harvest, is usually required to maintain a protective covering on these trees that is adequate to overcome the natural attractiveness of the fruit. For early apples, the lime-aluminum sulfate spray is recommended; for early peaches, nectarines, and plums, the rotenone spray is preferable. Two or three applications of aluminum sulfate, and applications of the rotenone spray at intervals of 7 to 10 days, are usually necessary to afford protection to the trees until harvest.

Fruits Ripening after the Height of the Beetle Season.—The fruit of apples, peaches, and plums ripening after the height of the beetle season is seldom eaten by the beetle, but the foliage of late-ripening varieties is often severely injured, and, unless protected, the fruit may be of poor quality. The lime-aluminum sulfate spray has been used with satisfactory results for the protection of the foliage of apple, peach, and plum trees. Lead arsenate may be substituted for the lime spray on apples, but is not recommended for peaches or plums because of the danger of arsenical injury. Two or more applications of these sprays may be required during the season. In the case of peaches, it is not advisable to apply a lime spray after July 15 because of the residue on the fruit at the time of harvest.

Spray-Residue Removal.—Any visible spray residues remaining on fruits sprayed with either the lead arsenate or lime-aluminum sulfate sprays should be removed by wiping or washing when the fruit is harvested.

Protecting Small Fruits

The foliage of bearing and nonbearing grapevines can be protected by spraying thoroughly with either the lead arsenate or the lime-aluminum sulfate spray. The spray should be directed downward from above to avoid excessive residue on the fruit at the time of harvest, but every leaf should be covered. Where it is the practice to use 8–12–100 bordeaux mixture [6] on the grapes in the latter part of June, lead arsenate without the flour may be added. Additional applications of these sprays are usually necessary to protect the new growth that develops after the first application.

Although the Japanese beetle does not ordinarily feed on grape berries, the fruit of such early-ripening varieties as Portland and Ontario may be attacked by the beetles, even though the foliage has been protected. Injury to these fruits may be largely prevented by prompt application of the rotenone spray, at double the usual strength, as soon as beetles are observed feeding on the ripening bunches. The spray should be directed particularly at the fruit.

It is difficult to protect ripening raspberries, blackberries, and blueberries when beetles are present in large numbers. Application of the rotenone spray will afford some protection, depending on the beetle population, ripeness of the fruit, and weather conditions. After the fruit has been harvested, the foliage can be protected by an application of the lead arsenate or the lime-aluminum sulfate spray.

[6] Copper sulfate, 8 pounds; hydrated lime, 12 pounds; water, 100 gallons.

Protecting Shrubs and Ornamentals

The foliage of ornamental plants may be protected from attack by maintaining a deposit of spray material on the foliage during the period when beetles are flying. On estates, in cemeteries, and in similar places where relatively large numbers of plants are involved, such protection can best be obtained from the application of the lead arsenate spray. However, in the case of parks, playgrounds, and home yards, where children are likely to play, a nonpoisonous spray should be used, either the lime-aluminum sulfate or the rotenone spray. If the rotenone spray is used and relatively few plants are concerned, requiring a small quantity of spray material, the rosin emulsion can be omitted from this spray. The lime-aluminum sulfate spray is not readily washed off by rain, but several additional applications may be needed during the season to protect the later developing leaves. The rotenone spray should be applied after each rain, and in clear weather at intervals of 7 to 10 days.

Many of the flowering ornamental plants are very often subject to severe attack from the beetles, particularly such plants as rose, hollyhock, shrub-althea, and zinnia. No spray has been found which will completely protect flowers highly attractive to beetles, as it is not possible to keep the unfolding bloom covered with a protective spray residue. The consistent application of either the lime-aluminum sulfate or the rotenone spray at frequent intervals, however, will reduce considerably the extent of damage. Roses are especially susceptible to attack and are difficult to protect. The most practical method is to protect the foliage by the application of the sprays previously mentioned, repeated as frequently as may be necessary. The buds, however, should be removed as they appear, since it is not possible to protect them from beetle attack. Disbudding should be discontinued after the beetles have largely disappeared. It has been found that plants treated in this manner will thereafter have a profusion of blooms of excellent quality, and will bloom later than if allowed to flower throughout the summer.

Choice rose and other ornamental plants may be protected from beetle attack by enclosing them with a cloth or wire netting on a wooden or metal frame. When roses are protected in this manner it may be necessary to apply a fungicide during July and August, as enclosed plants are more subject to mildew.

Protecting Vegetables

The foliage of truck crops commonly attacked by the beetle, such as string and lima beans, rhubarb, and asparagus, can be protected by spraying with the nonpoisonous lime-aluminum sulfate spray. In the home garden, vegetables can be protected by dusting them thoroughly with a good grade of fine hydrated lime alone. Repeated applications will be necessary, however, as the lime residue is readily removed by rain or wind.

Sweet corn is severely injured by beetles feeding on the silk as it grows from the husk, before pollination has taken place, thus preventing the formation of the kernels. Corn can be protected by dusting the tips of the ears with very fine (300-mesh) hydrated lime when the plants begin to show silk. The application should be made as soon as the first beetles are noticed, before they begin to accumulate on the ears. Following the first application, at least two additional applications should be made at intervals of 3 days. The effectiveness

of this treatment depends almost entirely upon placing the lime at the proper time on the tips of the ears; the need for extreme care in the application cannot be overemphasized.

This method has been found very effective in preventing injury in blocks of corn up to approximately 10 acres in size. In larger blocks, not already infested, it has been found that invasion by beetles coming from outside the block can be largely prevented by dusting the outer 8 to 10 rows. However, in large blocks already infested all the plants must be kept thoroughly dusted until pollination is completed throughout the field.

PREVENTING INJURY FROM GRUBS, OR LARVAE

Grubproofing Lawns and Other Turf Areas

It is possible to make an established lawn practically immune to injury by grubs of the Japanese beetle by applying lead arsenate. It is better to prevent injury to the grass by applying the poison before the density of the grub population is sufficient to cause damage, but if this has not been done, treatment should be made as soon as injury becomes apparent. This material can be applied at any season when the ground is not frozen, but the best results are obtained if it is applied before July. An application of lead arsenate at the rate of 10 pounds to 1,000 square feet of turf area is recommended. This small quantity of lead arsenate must be diluted to a greater bulk so that it can be uniformly distributed over the surface. The material may be mixed with about 25 times its volume of moist sand, soil, or other suitable material, and broadcast by hand, or with a hand-operated fertilizer distributor (fig. 15). Immediately after lead arsenate has been applied the lawn should be well watered with a hose to wash the poison into the soil. It may be expected that a lawn treated in this manner will be immune to injury by the grubs for at least 5 years.

After the treatment has been applied to a lawn, the normal operations of mowing, watering, and fertilizing can be carried on as usual. Lime should be used on poisoned grass only when necessary to correct the acidity of the soil. The addition of hydrated lime, or stone lime, except for the purpose mentioned above, is not recommended because lime has been found to reduce the effectiveness of the insecticidal treatment.

Precautions in using lead arsenate.—Lead arsenate is poisonous to man and animals. Considerable care should be exercised in handling it, so as to avoid inhaling the dust. It may be mixed and otherwise manipulated with the bare hands, but, since it is possible that the poison may be absorbed into the system through cuts and abrasions of the skin, it is advisable to protect the hands. The worker should keep the hands away from the mouth and wash them thoroughly before eating. Children and domestic animals should be kept from playing or feeding on the recently poisoned turf until the lead arsenate has been entirely removed from the blades of grass by watering or rain. The extensive use of lead arsenate on lawns within the heavily infested area has not caused any known damage to poultry or native birds that feed on earthworms and grubs in the soil.

For treating large turf areas, such as large estates, parks, and golf courses, the same material, lead arsenate, should be used, but other equipment is needed for such large-scale work. The lead arsenate may be applied either dry, with a suitable carrier, by means of a ma-

chine distributor, or as a spray, applied by a power sprayer and washed into the soil immediately after application before it has dried on the grass. Before undertaking the treatment of large areas, more detailed information should be secured.[7] The treatment of pasture land is not recommended.

Treatment of Flower Beds and Gardens

The grubs of the Japanese beetle are generally not sufficiently numerous in flower beds and vegetable gardens to cause appreciable

FIGURE 15.—Applying lead arsenate mixture with a small fertilizer distributor for grubproofing turf.

damage to the roots of the plants. Occasionally the roots of flowering plants such as calendula, rose, dahlia, peony, and snapdragon and of garden crops such as strawberry, beet, onion, and bean are injured. The use of lead arsenate is not recommended in flower beds, shrubbery borders, or vegetable gardens, as the available evidence shows that some of the ornamentals will not grow in soils containing this material. Many of the vegetables will grow in land treated with lead arsenate, but enough of the poison may be absorbed by the roots to be detrimental to health.

Turning the soil late in the fall, or carefully working it in the spring and killing the larvae that are found, or permitting chickens to run in the garden until seeding time is useful in reducing the number of larvae in the garden.

[7] For more detailed information on the treatment of large turf areas, see U. S. Department of Agriculture Circular 403, Preventing Injury from Japanese and Asiatic Beetle Larvae to Turf in Parks and Other Large Areas.

U. S. GOVERNMENT PRINTING OFFICE: 1940

For sale by the Superintendent of Documents, Washington, D. C. - - - - Price 5 cents